UNITED STATES DEPARTMENT OF AGRICULTURE



# SURVEY REPORT

# VIRGIN RIVER WATERSHED

## UTAH, ARIZONA & NEVADA

## 1951



MAY 1952

UNITED STATES DEPARTMENT OF AGRICULTURE

# VIRGIN RIVER WATERSHED
# UTAH, ARIZONA, AND NEVADA

## PROGRAM FOR RUNOFF AND WATERFLOW RETARDATION AND SOIL EROSION PREVENTION

Pursuant to the Act of June 22, 1936 (49 Stat. 1570)
as amended and supplemented

1951
(Revised May 1953)

# INTRODUCTION

Authority.--This survey report is submitted under the provisions of the Act approved June 22, 1936 (49 Stat. 1570), as amended and supplemented.

Scope.--This report outlines a program of watershed treatment for runoff and waterflow retardation and soil erosion prevention needed in the Virgin River Watershed in southwestern Utah, northwestern Arizona, and southeastern Nevada. The Virgin River Watershed as considered in this report consists of the pre-Lake Mead drainage area of about 17,233 square miles (11,029,120 acres) and includes the Muddy and White River drainages. The Virgin and Muddy Rivers now empty directly into Lake Mead.

The watershed program is composed of two groups of measures. One group consists of measures primarily for flood prevention, hereinafter called flood prevention measures (A Measures), which are not now normally being installed under existing authorities for current national programs of the Department of Agriculture. The other group consists of measures used for the conservation of watershed lands which contribute directly to flood prevention, hereinafter called land treatment measures (B Measures), and which are being installed under existing authorities for such programs.

This report presents recommendations for authorization of the flood prevention measures under the Flood Control Act of June 22, 1936, as amended and supplemented, and for installation of the land treatment measures under existing authorities concurrently with the flood prevention measures.

Need for the Watershed Program.--A survey of the Virgin River Watershed revealed that serious flood and sediment problems exist and that extensive damages have occurred. It was also found that depletion of plant cover and erosion of the soil mantle has increased flood and sediment damages. With continued depletion of the protective plant cover and further gullying and other forms of erosion on mountain, foothill, and bottom lands the flood and sediment problem will become more critical and damages will increase. Future damages are estimated at $438,400 annually.

A remedial program is needed which will reduce the present accelerated rates of erosion, surface runoff, and sediment production and thus materially lessen the property damage and other losses in the basin. The program will stabilize the soil, benefit the water resource, and perpetuate the local economy much of which is dependent upon the public lands involved. The program will also produce significant benefits in reducing rates of sediment deposition in Lake Mead and thereby aid in perpetuating the downstream benefit which Lake Mead and Hoover Dam provides. In addition, the program will provide certain conservation benefits including additional forage for livestock, and increased production from timber and crop lands.

## RECOMMENDATIONS

It is recommended that:

(a) The Secretary of Agriculture be authorized to install the flood prevention measures on a cost sharing basis[1/] with local

1/ The share of the cost to be borne by local interests may consist of cash, labor, materials, equipment, land, easements, rights-of way, and other contributions.

interests during a 10-year period in the Virgin River Watershed in Utah, Arizona and Nevada, under the provisions of the Act of June 22, 1936, as amended and supplemented, except the measures which are proposed for installation on land under the jurisdiction of a Federal agency other than the Department of Agriculture, and that the head of such other Federal agency be authorized to install the flood prevention measures which are proposed for installation on land under the jurisdiction of such agency. The estimated total Federal cost of all flood prevention measures is $4,327,100.

(b) The land treatment measures, for which no additional authority is requested herein, be applied under existing authorities concurrently with the installation of the flood prevention measures to assure the proper functioning of the program.

(c) As a condition precedent to the installation of the program, cooperating State and local agencies be required to furnish assurances satisfactory to the Secretary of Agriculture with respect to their ability and willingness to operate and maintain the flood prevention measures on non-Federal land.

(d) The authority of the Secretary of Agriculture, or the head of any other Federal agency concerned, to carry out the flood prevention measures shall be supplemental to all other authority vested in him, and that nothing in this report shall be construed to limit the exercise of powers heretofore or hereafter conferred on him by law to carry out such measures or other measures that are similar or related thereto.

(e) The Secretary of Agriculture, or the head of any other Federal agency concerned, be authorized to construct such buildings and other improvements as are needed to carry out the flood prevention measures.

## DESCRIPTION OF THE WATERSHED

Location and Size.--The Virgin River Watershed, a part of the Colorado River Basin, comprises an area of about 17,233 square miles (11,029,120 acres) in southwestern Utah, northwestern Arizona, and southeastern Nevada (see map). Of the total area, 12,340 square miles lie in Nevada, 2,943[2/] square miles in Utah, and 1,950 square miles in Arizona. The Virgin River Watershed as considered in this report consists of the pre-Lake Mead drainage and includes the Muddy and White River drainages.

The Virgin River proper, draining an area of about 6,107 square miles, rises in southwestern Utah at elevations up to 10,000 feet and flows southwesterly across the northwestern corner of Arizona and empties into Lake Mead in Clark County, Nevada.

Muddy River, the largest drainage tributary to the Virgin prior to Lake Mead, comprises about 4,318 square miles wholly within Nevada. Muddy River proper rises in the western part of the basin and flows southeastward about 60 miles emptying into Lake Mead near Overton, Nevada. Its principal tributary, Meadow Valley Wash, originates in the northern part of the basin and flows southward about 95 miles to join Muddy River near Glendale, Nevada.

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2/ Does not include 40 square miles in the vicinity of Kanarraville, Utah which was included in the Department of Agriculture's flood control survey report on the Sevier Lake Watershed, Utah dated 1950.

Pine & Matthews Canyon Dams
Corps of Engineers
(Authorized)

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SCALE 0 3 0 4 8 10 MILES

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
OGDEN, UTAH

FLOOD CONTROL SURVEY

# VIRGIN RIVER WATERSHED
(UTAH, NEVADA & ARIZONA)

## GENERAL

SUBMITTED _____ DATE

APPROVED

The White River drainage and adjacent closed basins in the northwestern portion of the watershed, about 6,379 square miles in extent, is comprised of a series of ephemeral intermittent stretches alternating with occasional perennial stretches supplied by important consistently flowing springs. Very little, if any, water from this area has reached Muddy River as surface flow during recent times.

About 429 square miles of the pre-Lake Mead drainage now drains directly into the lake or is now inundated.

Physiography and Geology.--The watershed includes parts of the Colorado Plateaus and the Basin and Range Province. The Colorado Plateaus, roughly separated from the Basin and Range Province by the Hurricane fault, cover the easternmost one-fifth of the watershed and are characterized by extensive remnants of nearly level plateaus 5,000 to 10,000 feet above sea level that are separated and cut by breaks in association with occasional mountain masses. The rocks making up this portion are mostly sedimentary in origin and range in age from Carboniferous to Tertiary. Limestones, sandstones, conglomerates, and shales are predominating but are locally capped by lava flows.

The Basin and Range Province covers the remaining four-fifths of the watershed and its characteristic feature is a series of serrated mountain ranges and intermontane plains or valleys extending in a north-south direction. The plains or valleys, formed by outwash from the mountains, vary in elevation from about 1,500 feet in the south to about 6,000 feet in the north with the mountain ranges

generally 3,000 to 5,000 feet higher than the adjoining plains. The rocks in this province are chiefly Paleozoic limestones, shales, quartzites, Tertiary lavas and tuffs. Valley fills are interbedded clay, silt, sand, gravel, cobbles, and occasional boulders.

Climate.--An arid climate prevails in the lower portions of the watershed including most of the Muddy and White River drainages, while the upper portion is generally semiarid to subhumid. Average annual precipitation varies from less than 5 inches at the lower elevations to about 25 inches in the mountainous areas with most of the watershed receiving less than 10 inches. Precipitation in the mountainous areas is largely in the form of snow and most of the water yield of the basin comes in the spring from snow melt in these higher areas. Less than half the annual rainfall comes during the growing season. Mean temperatures range from about 40° to 60° F. annually and temperature extremes of -31° and 120° F. have been recroded. The growing season in the principal agricultural valleys averages about 220 days but drops to about 80 days in the mountainous areas. Flood-producing fall and winter storms at the higher elevations have resulted in recorded precipitation of from 3.5 to 4.1 inches in 24 hours. Summer storms of 2.0 to 2.5 inches in 1 to 2 hours with intensities of approximately 4.5 inches per hour for 5-minute intervals are frequent.

Soils and Erosion.--Valley soils derived principally from alluvium and lesser amounts of lake-laid material are found on about 39 percent of the watershed. Approximately one-half of these soils are underlain by a caliche layer generally at depths of less than

2 feet. The remaining soils are deep and highly productive when water is available. Generally erosion is not serious within this group.

In the mountainous portion of the watershed, sedimentary soils occupy about two-thirds of the area and are largely derived from limestones. Soils formed from igneous materials, principally rhyolites and trachytes, occupy the remainder of the area. These mountain soils occupy about 38 percent of the watershed area and with the exception of the shallow and erosive rhyolite soils are moderately deep and subject to slight erosion.

Soils of the plateaus representing 21 percent of the watershed area are derived in roughly equal areal proportions from sandstones, limestones, lavas, and shales. This group is generally susceptible to erosion and varies in depth from the relatively deep limestone soils to the shallow and highly erosive shales and argillaceous sandstones.

The remainder of the basin is composed largely of badlands having no true soil and with apparently high rates of normal geologic erosion.

Accelerated erosion is occurring on over 80 percent of the direct drainage area varying in severity with the kinds and condition of cover, steepness of slope, type and depth of soil, and use. Severe accelerated erosion is occurring on about 4 percent of the area, moderate erosion on 24 percent, and slight erosion on 53 percent. Normal erosion is occurring on the remainder of the area.

Accelerated erosion has resulted principally from overuse and fires on range lands, improperly drained roads and trails, and cultivation of lands with excessive slopes in relation to the management practices used. Excess runoff resulting from such practices has caused destructive gullying and channel cutting in many parts of the watershed. The irrigation of many inadequately leveled fields results in erosion and the sediment so produced damages lower lying fields and irrigation ditches. A significant part of this sediment is also discharged into the river system and thence into Lake Mead.

Sedimentation.--A great quantity of sediment is produced within the watershed as a result of conditions conducive to accelerated runoff and erosion. Of the sediment produced, an estimated 5,750 acre-feet enter Lake Mead annually of which 5,000 acre-feet are contributed by the Virgin River area. The gross production is substantially higher since large amounts are deposited on mountain meadows, flats, farm lands, or in channels or other areas and have not yet reached the lake. Channel aggradation has become an important problem in the St. George area and also in the section between Mesquite and Lake Mead.

The average annual sediment production rate per square mile for the entire Virgin River portion of the watershed is about 0.9 of an acre-foot. However, 49 percent of this part of the watershed produces about 1.0 to 1.9 acre-feet per square mile per year, and 14 percent produces 2.0 to 5.0 acre-feet per square mile per year. Practically all of the sediment originates from water erosion with

an estimated 60 percent resulting from gullying and trenching, 10 percent from bank cutting, and the remainder from sheet erosion. Of the total load carried by the stream, suspended sediment load consisting mostly of silts and clays constitutes about 55 percent. These sediments largely originate from farm lands in the valley; from widespread exposures of Moenkopi, Chinle, and Wasatch shales, and from alluvial soils in the tributary valleys which are now undergoing extensive trenching and gullying. Bedload makes up the remainder and is composed chiefly of fine sand that originates from terraces, farm lands, and sandy shales at the lower elevations.

In the Muddy River-Meadow Valley Wash area the present contribution to Lake Mead is relatively small and is estimated at 400 acre-feet annually. This drainage was originally composed of a chain of wet meadows separated by narrow constrictions that acted as natural sediment traps. Many of these meadows have been, or are now cutting out, but enough of them remain to materially check the downstream movement of sediment. Sediment production from this area as represented in downstream deposits is potentially great if trenching of the existing meadows is allowed to continue.

The area above the pre-Lake Mead junction of the Virgin and Muddy Rivers that now drains directly into the lake is composed of erosive shales that are being dissected rapidly. The on-site rate here is esentially the downstream rate and the annual amount of sediment entering the lake has been estimated at 350 acre feet.

Plant Cover.--A plant cover of great diversity is found on the watershed ranging from the southern desert shrub type in the arid

lower portions to small areas of the subhumid spruce-fir type in the highest mountains. For the watershed as a whole, the desert shrub type consisting mostly of creosote bush, blackbrush, and sagebrush, covers about 57 percent of the area; woodland type, primarily composed of Utah juniper and pinyon pine, about 30 percent; the mountain brush type, with oakbrush predominating, about 3 percent; and the forest type, composed largely of ponderosa pine, spruce, fir, and aspen, about 1 percent. The grass type found in the eastern portion of the watershed, mostly in Arizona but also on the Kolob Plateau in Utah, occupies about 4 percent of the watershed area. Cropland, comprising about 73,900 acres or less than 1 percent of the drainage area, is found scattered throughout the basin principally in the lower and intermediate valleys. The remainder of the watershed has been classified as water surface or barren.

The impact on cover by overuse is in evidence over much of the watershed and has resulted in elimination or reduction of desirable forage plants with replacement by inferior species, decrease in cover density and related site protection, and resultant disturbance of the soil mantle.

History of Development and Population.--A colony of Mormon pioneers established the first white settlement in the watershed on the Santa Clara River in 1854. Within two decades subsequent migrations resulted in the establishment of most of the communities now existing in the Virgin Valley. Similar migrations resulted in the first settlement of the Muddy River Valley in 1866 and Meadow Valley Wash in 1868. The discovery of silver at Pioche in 1869 resulted

in rapid settlement of that community and with the establishment of Preston and Lund in the White River drainage in 1896 the entire watershed was settled in about its present pattern.

Development of the watershed has been generally dependent upon agriculture. Due to the necessity for irrigation, early settlers selected bench lands and alluvial fans adjacent to perennial streams for their self-sufficient village type agricultural communities. At first, special crops including cotton, dates, and citrus crops were grown as well as the staple grains and vegetables. However, the specialized crops did not prove successful and farming has shifted to other lines with fruits and vegetables becoming of increasing importance along with the production of sugar beet seed and tomato seedlings.

Lack of transportation facilities, distance from market, and availability of extensive range areas stimulated livestock production. Cattle raising was predominant until about 1900 when number of sheep began to increase and total livestock numbers increased until about 1920. Between 1920 and 1930 cattle numbers decreased sharply and since 1930 the trend in total livestock use has been slowly downward.

By 1949 the population of the watershed had reached an estimated total of about 18,300 or about one person per square mile with most of the population concentrated in small communities in the valley bottoms. Population growth has been slow due to a continuous exodus of young people from the basin because of lack of employment opportunities.

Land Ownership.--Of the 11,030,000 acres in the watershed about 92 percent or some 10,100,000 are in Federal ownership. Of the 92 percent in Federal ownership more than 83 percent is public domain and is practically all within organized grazing districts. National forest land constitutes about 6 percent of the watershed area. Located in the higher portions of the watershed these lands include portions of the Dixie, Kaibab, and Nevada National Forests. Other Federal lands include the scenic Zion National Park and Monument, portions of Cedar Breaks National Monument and Lake Mead National Recreational area, and a small amount of Indian lands. Private holdings are largely confined to cultivated lands and to range lands strategically located with reference to stock water. In Utah, extensive areas of summer grazing lands are privately owned. State lands constitute about 2 percent of the total and are largely comprised of school sections in the States of Utah and Arizona. Table 1 indicates the areal extent of the various land ownerships involved.

Major Land Uses.--Livestock grazing is the major land use of the watershed and is the dominant use on about 94 percent of the area. About 3 percent is devoted to recreational use, 0.6 percent to cultivated crop production, 0.4 percent to timber production with the remainder used for mining, urban developments, and miscellaneous.

In areal extent and in wealth produced the production of livestock is the most important enterprise within the watershed. Extensive range areas with a wide variation in climatic conditions permit year-around grazing of cattle and sheep with the lower areas utilized in the winter, the higher areas in the summer and those at

Table 1.--LAND OWNERSHIP, VIRGIN RIVER WATERSHED

| Classes of ownership | Acres | Percent |
|---|---|---|
| Federal Government | | |
| Public domain within grazing districts | 9,146,866 | 82.9 |
| Public domain outside grazing districts | 19,480 | .2 |
| National forest | 602,232 | 5.5 |
| National parks, monuments and recreational areas | 284,322 | 2.6 |
| Indian lands | 35,688 | .3 |
| Other Federal | 9,480 | .1 |
| Total Federal | 10,098,068 | 91.6 |
| State | 189,320 | 1.7 |
| Private | 741,732 | 6.7 |
| Total | 11,029,120 | 100.0 |

intermediate elevations during the spring and fall. While use has fluctuated with market conditions livestock numbers reached their peak around 1920. At that time, numbers were greatly in excess of carrying capacity resulting in serious damage to the range. Between 1920 and 1930, numbers, especially of cattle, were drastically reduced. While there has been improvement in management practices and some further reduction in numbers since that time, present use is still in excess of carrying capacity. Proper distribution to obtain uniform utilization of the available forage is difficult due to inadequate fencing and lack of water. Use by cattle as compared to

sheep has fluctuated according to price relationships. At the present time use by cattle predominates. Cattle are generally resident-owned while most of the sheep are brought in from outside the watershed for winter grazing at the lower elevations. Estimated livestock use, exclusive of big game within the direct drainage area, is 320,000 animal unit months.

Big game use of the watershed is of importance expecially in the Utah portion where large numbers of deer and a few elk are found at the higher elevations. A small number of mountain sheep are found in the mountains in the Nevada portion of the drainage. The major big game problem within the direct drainage area is over-use of winter range by deer. This is largely confined to the pinyon-juniper and mountain brush types at the intermediate elevations in Utah. Present estimated range use by big game within the Virgin and Muddy River drainages is about 46,000 animal unit months. Stream fishing is of importance although limited in extent, being confined largely to the perennial mountain streams in Utah. Fishing in Lake Mead is one of the primary attractions in that area. The Desert Game Range, a wildlife refuge is partially within the watershed in Nevada.

The production of poultry and poultry products, including the growing of turkeys, is favored by climatic conditions and market outlets and has become increasingly important. Expanded market outlets have also resulted in an increase in dairying during recent years especially in the Nevada portion of the watershed. In 1944 livestock and livestock products including dairy and poultry accounted for about 63 percent of the value of all farm products sold.

There are about 73,900 acres in cultivation within the watershed of which 44,700 are irrigated. Irrigated lands are located along perennial streams or stretches of intermittent streams that are fed by springs. In the higher valleys principal crops grown are hay, grain and alfalfa. In the lower valleys, largely in the Middle and Lower Virgin River area and in the Moapa Valley, truck crops, fruit, sugar beet seed, and seedling tomato plants are the more important crops produced. With recent improvements in transportation facilities, truck crops and fruit have become increasingly important since the relatively early growing season permits placing these crops on nearby markets, before similar crops from surrounding areas are available.

Dry-farm lands are located in scattered units principally in the Utah portion of the watershed. Because of low rainfall, dry-land farming is as a rule precarious and crops are limited principally to wheat which is alternated with fallow. These dry farms are usually located on sloping lands and on most of them accelerated erosion is occurring. During recent years, additional areas of these sloping lands have been brought into production thus accentuating the sediment problem.

The farm settlement pattern is typical of many other Mormon communities with farm operators generally living in villages and commuting to and from their farms. Full owners operate 17 percent of the land in farms, part owners 48 percent, tenants 5 percent, and managers 30 percent. Farms are exceptionally small when measured either in terms of cultivated area or farm income. While the

average size of farm is 283 acres, the average irrigated area is only 19 acres. In 1944 approximately 378 or 33 percent of all classified farms in the watershed produced less than $1,000 worth of products. Due to lack of water, opportunities for expansion are extremely limited and as a result many must supplement their farm income from outside employment. It is estimated that 22 percent of the total cash income is derived from outside sources.

Recreational use is becoming increasingly important in the basin. Scenic attractions, together with opportunities for camping, boating, fishing, and hunting have caused many people to visit the area. In 1949 Zion National Park and Monument were visited by about 347,000 people. Lake Mead is a popular fishing, boating, and camping area, and on the national forests camping and fishing are enjoyed and deer abound, attracting many hunters from Utah, Arizona, California, and Nevada. Income derived by providing services to this annual influx of people contributes importantly to the economy of the watershed.

Other uses, while smaller in areal extent, are important within the watershed. Timber operations include the cutting of ponderosa pine for lumber and aspen for excelsior. Thousands of cedar (juniper) posts are cut annually for use on the nearby range lands. Mining is largely concentrated in the Pioche area in Nevada and at one time this area was the second largest producer of silver in western United States. At the present time lead and zinc are the principal metals mined with smaller amounts of gold, silver, and copper being produced. In the Muddy River Valley deposits of sand suitable for

glass manufacture are important and in 1947, 200,000 tons of this sand was shipped to Los Angeles for processing.

Water Supply.--Of the 44,700 acres under irrigation, less than 50 percent have an adequate water supply and except during the spring runoff or periods of abnormal high flow practically all water is diverted for irrigation purposes. The irrigated lands are nearly all supplied by distribution systems owned and operated by water companies made up of groups of farmers. Distribution is accomplished by simple gravity systems and very little regulatory storage exists. A small amount of pumping is now going on. The quality of the water is generally satisfactory except for a few areas where, during periods of low flow, most of the water originates from springs, seeps, or subchannel flow and is high in dissolved salts. Siltation is an important problem and because of the high percentage of sediment in the diverted water, frequent releveling of fields, cleaning of distribution systems, and operation and maintenance of sand traps is necessary. The average annual amount of water diverted for irrigation ranges from about 6 acre-feet per acre in the lower valleys to 4 acre-feet at the higher elevations.

Most of the towns and communities have municipally owned domestic water systems adequately supplied by springs. There are five hydro-electric power plants in the watershed with a total installed capacity of 3,875 kv.-a.

Transportation.--Rail facilities are confined to the Nevada portion of the watershed. The main line of the Union Pacific Railroad between Los Angeles and Salt Lake City, established in 1905,

crosses the Nevada portion of the watershed with branch lines extending from Caliente to Pioche and from Moapa to Lake Mead. The main line closely parallels portions of Clover Creek and Meadow Valley Wash and has suffered severely from flood damages in the past.

Highway facilities consist of three Federal highways, U.S. 89, 91, and 93, Utah State Highway 15, and other State and county roads.

## FLOOD AND SEDIMENT PROBLEMS

Flood History.--Many of the early villages have been destroyed by floods or moved to new locations to escape the flood menace. Since 1863, about 100 floods have been reported on the Virgin River and its tributaries with 70 of them occurring during the summer months. Twenty-four floods are of record in the Muddy River drainage since 1906 of which 8 were summer floods. Numerous floods have occurred on the smaller tributaries and washes and although local in extent are important in total due to their frequency. Floods from general winter storms have caused extensive damages especially in the Nevada portion of the basin. However, recently authorized projects are designed to alleviate this danger.

Causes of Floods and Flood Damages.--Human factors have accentuated natural factors in increasing the frequency and size of floods and sediment production.

The principal natural factors are the frequent occurrence of high intensity summer storms, topography that favors concentration of runoff, a naturally sparse vegetal cover, and extensive areas of shallow soils.

Human factors that have accentuated the problem largely consist of developments that are within or encroaching upon the flood plains, improper land use, and location of highways and railroads without proper safeguards against the flood hazard.

Before settlement, the well vegetated valley bottoms checked silt movement and runoff and stabilized stream banks. Rapid development of these lands following settlement eliminated this vegetation in many places and exposed them to gullying, bank cutting, deposition, or other damage by flooding from the numerous side washes or the main stream. Floods from the side drainages now wash out irrigation canals or damage other improvements and often carry across cultivated lands to deposit their load of silt in the main channel. This silt is flushed downstream during periods of high flow to be deposited in reservoirs and irrigation distribution systems or remains within the channel itself causing aggradation with its resultant problems. In the higher areas, many of the small valley floors are situated in a perched condition and as a result of misuse headward moving cuts in numerous places have caused important land losses as well as added to the sediment load of the streams. Most of the urban areas are located in the valley bottoms or mouths of canyons and many are subjected to flooding, especially from side tributaries.

Present management of dry-farm land does not provide for maximum infiltration of precipitation and makes little provision for arresting erosion. During recent years market conditions have caused additional areas of these more sloping lands to be brought into production adding to the existing erosion and sediment problem.

On range lands, overstocking, lack of water developments, and other poor management practices have resulted in decreased cover density and disturbance of the soil mantle. Stock driveways following trails or roads along streams to the higher areas are often in serious condition due to overgrazing and trampling. In the lower areas thousands of acres are burned annually thus destroying vegetation that will take years to restore.

Roads have been constructed without sufficient regard to drainage facilities and a considerable portion of the railroad system is located in close proximity to water courses and has suffered severe damages from flooding.

Evaluated Damages.--It is estimated that future annual damages within the watershed will amount to about $438,400, of which $220,300 is attributed to floodwater and $218,100 to sedimentation.

Roads and railroads have suffered from washout or impairment of bridges, culverts, fills, and roadbeds, and the rerouting of traffic and loss of time involved has added to such damages.

The small farm and low income problems prevalent in the watershed add to the importance of the agricultural losses due to floods. Streambank cutting and gullying are resulting in land loss and also loss in production from adjacent lands due to excessive drainage. In many areas where livestock operations may be dependent upon small tracts of meadow land for supplemental feed the loss of this land by gullying and subsurface drainage is jeopardizing such livestock operations and use of the surrounding range. On cultivated farm lands, bank cutting reduces the small amount of cultivated acreage

and gullying isolates small tracts or prohibits the use of strips of land along such gullies due to the danger of operating equipment close to the banks. The necessity for releveling irrigated fields due to sediment deposition by irrigation water is important especially in the Virgin River area. Other important agricultural losses include the washing out or filling with drbris of diversion dams and canals, inundation or soaking of crops, deposition of debris on cultivated areas, and damage to equipment, fences, and loss of livestock.

Many of the residential areas are subject to damage largely from local tributaries or sidewashes. The community of Ursine, Nevada, situated in the mouth of a side canyon, is especially vulnerable. Caliente, Nevada, located on Meadow Valley Wash where Clover Creek enters the stream from the east, has suffered severely in the past from floodwaters. However, the recently authorized construction of two flood control dams by the Corps of Engineers on tributaries of Clover Creek is expected to alleviate the flood danger to the town from this source. Antelope Creek, entering Meadow Valley Wash from the west just above the town, is still a hazard. Other communities subject to flooding include Logandale, Panaca, and Overton, Nevada, and St. George, Gunlock, and Springdale, Utah. Additional floodwater losses occur from damage to power and communication facilities. Sediment deposits have also reduced the effectiveness of flood protection works constructed by the Civilian Conservation Corps in the 1930's which have been inadequately maintained.

Deposition of sediment in reservoirs, irrigation canals, and ditches is causing extensive damages. The capacities of several small reservoirs within the watershed have either been drastically reduced or the reservoirs have been completely filled by sediment. An estimated 5,750 acre-feet of sediment mostly from the Virgin River portion of the watershed is deposited annually in Lake Mead constituting about 4.6 percent of the estimated future total annual deposition of about 125,000 acre-feet in that reservoir. Other sediment damages include costs of installing and operating sand traps, frequent cleaning of canals and ditches, and in some instances the bypassing of sediment-laden water or the use of such water containing sediments harmful to the land.

Table 2 is a summary of the average annual flood and sediment damages based on current average prices.

Nonevaluated Damages.--In addition to the evaluated damages, there are other damages that are difficult to evaluate monetarily. At least five lives have been lost as the result of floods. In some cases, lands have been relegated to lower use due to potential flood and sediment hazards. The bypassing of water needed for irrigation due to its high concentration of harmful sediment often occurs and has undoubtedly resulted in lower crop yields. The loss of topsoil with its high concentration of plant nutrients through erosion represents a huge loss.

## CURRENT AND PAST FLOOD CONTROL ACTIVITIES

No large-scale, concerted effort towards installation of flood control measures has been undertaken over the basin as a whole.

Table 2.--ESTIMATED AVERAGE ANNUAL VALUE OF FUTURE FLOOD DAMAGE, VIRGIN RIVER WATERSHED

| Type of Damage | Damage |
|---|---|
| Agricultural | $ 103,500 |
| Residential | 16,700 |
| Utilities and public property | 17,300 |
| Railroads | 61,300 |
| Roads and highways | 65,900 |
| Flood protection works | 6,500 |
| Sediment deposition in canals and ditches | 49,600 |
| Sediment deposition in reservoirs | 168,500 |
| Total | $ 489,300 |
| Less reductions attributable to authorized projects | 50,900 |
| Uncontrolled damages | $ 438,400 |

Locally steps toward flood control have been taken by Federal and State agencies, local communities, and individuals.

During the period 1933 to 1942 a number of flood and sediment control works were installed in cooperation with the Civilian Conservation Corps or other relief agencies. The larger structural improvements were mostly concentrated in the Nevada portion of the drainage. Smaller works designed to arrest gully erosion and streambank cutting and to protect irrigation systems and residential communities were installed at various places throughout the watershed.

At the present time several Federal agencies are active within the drainage and the extent to which their programs contribute to flood and sediment control varies with the nature and location of the work. On Federal lands conservation programs of most of the managing agencies contribute to the alleviation of flood and sediment problems although the funds for such work are extremely limited in relation to needs. On non-Federal lands the application of soil and water conserving practices, some of which are pertinent to flood and sediment control, are encouraged by such means as direct aids or by supplying technical services and educational assistance.

Department of the Army.--House Document No. 530, 81st Congress, reported upon a survey of Meadow Valley Wash and the Lower Muddy River by the Corps of Engineers. The report recommended the construction of two flood control reservoirs at a cost of $1,986,000 on Clover Creek which enters Meadow Valley Wash near Caliente, Nevada. This work has been authorized by Public Law 516, 81st Congress, 2nd Session, H.R. 5472, but construction has not yet begun.

Department of Agriculture.--The Agricultural Conservation Program is carrying on a program throughout the watershed by making direct aid available to land owners or operators for the application of soil and water conserving practices. Measures that have been put into effect as a result of this program and which contribute to flood and sediment control consist of water developments, terracing, diversions, erosion control dams, streambank protection, fencing, fire protection, removal of undesirable plants, reseeding, tree planting, land leveling, and other approved farm or range management practices.

The Extension Service conducts educational activities for agricultural programs in the basin which result in the adoption or acceleration of soil and water conservation measures some of which contribute to flood and sediment control. In the Nevada portion of the watershed especially, much attention has been given by this agency to flood and sediment problems and flood control committees have been organized to attack the problem more effectively.

The Soil Conservation Service furnishes farmers and ranchers who are cooperating with soil conservation districts the technical service they need to develop and apply effective conservation plans. Twelve soil conservation districts have been organized within the watershed and include within their boundaries practically all of the private lands. With help from these districts, land operators are developing soil and water conservation plans and applying practices, many of which contribute to the retardation of runoff and soil erosion prevention. Such practices considered pertinent to flood and sediment problems include construction of diversion and soil saving dikes, terracing, land leveling, streambank protection, crop residue management, reseeding of pastures and range land, and adjustments in seasonal grazing use and livestock numbers commensurate with forage production.

During the period 1933-42 the Soil Conservation Service, in cooperation with the Civilian Conservation Corps, installed improvements in several places in the watershed. Work performed largely consisted of structural installations designed to improve channels, alleviate or prevent gully erosion, and protect irrigation systems

and residential communities. Also installed were limited amounts of such land treatment measures as terracing, furrowing, fencing, and reseeding. In several places range demonstration areas were established.

The Forest Service administers the Dixie, Kaibab, and Nevada National Forests, about 602,000 acres of which lie within the watershed, and in its management stresses the importance of watershed protection to reduce floods and erosion and to insure and improve other values these lands afford. When the forest reserves were established they were placed under regulated use to facilitate improvement and maintenance of the land resources. Many improvements have been made on these lands. Modifications in seasonal grazing use, adjustment in numbers of livestock and game, the application of approved timber management practices, organized fire protection on Federal lands, and cooperative fire protection with states and counties on lands adjacent to the Dixie National Forest under the Clark-McNary program are among the major accomplishments. Other measures of value for flood and erosion control now being installed include reseeding, fencing, and treatment of mountain roads to prevent erosion.

During the period 1933-42 the Forest Service in cooperation with the Civilian Conservation Corps constructed five flood control or sediment detention works in the lower Muddy River area. The improvements constructed include the Wells Siding Dam and Bowman Reservoir a few miles below Glendale, the White Narrows and Hogan Wash Dams above the Moapa Indian Reservation, and Arrowhead Canyon Dam on the

upper Muddy River and the Meadow Valley Wash spreading grounds about 7 miles above Glendale. These structures have been effective for the purpose for which constructed but their efficiency has been reduced due to sediment accumulations and lack of maintenance.

Department of the Interior.--The Bureau of Land Management administers about 83 percent of the watershed area, practically all of which is within five organized grazing districts. Management of these lands is designed to protect the lands, permit the highest use of the forage and other resources, and at the same time retard soil erosion and facilitate flood control. Through its soil and moisture conservation program this agency has been installing a limited amount of improvements which contribute to the alleviation of flood and sediment problems. Measures currently being performed include removal of undesirable plants, reseeding, fire protection, fencing, and the installation of water developments.

The Bureau of Reclamation has prepared a preliminary report on the Dixie Project for the Virgin drainage in Utah. The report proposes the construction of two dams to conserve the waters of the Virgin and Santa Clara Rivers for the purpose of furnishing a supplemental water supply to existing irrigated areas, for development of additional irrigable acreage not now irrigated, and for the production of hydro-electric power. Additional benefits which would accrue consist of flood control, sediment control, recreation, and fish and wildlife conservation. One the proposed dams would be located on the Virgin River near Virgin City, Utah, and would create a reservoir of 246,000 acre-feet capacity including an allowance of

180,000 acre-feet for sediment storage. The second dam would be constructed on the Santa Clara River near Lower Gunlock, Utah and would create a reservoir of 24,000 acre-feet capacity of which approximately 10,000 acre feet would be provided for sediment.

In its investigations the Bureau of Reclamation has recognized the need for a watershed treatment program above the proposed reservoirs to reduce siltation. With installation of this or similar projects the protection afforded by an upstream treatment program will result in greater benefits than those claimed under present conditions. One phase of the investigations by the Bureau of Reclamation in connection with the Dixie Project was a field study of existing watershed conditions above the project area.

The Bureau of Reclamation has made a similar study of the Muddy River drainage in Nevada and has prepared a preliminary report entitled "Report on Moapa Valley Project, Nevada" which was released in August, 1951.

The National Park Service administers Zion National Park, Zion National Monument, Cedar Breaks National Monument and Lake Mead National Recreational area all or portions of which are within the watershed. In its management of these lands the preservation and improvement of their scenic and recreational aspects are stressed as well as watershed protection to prevent erosion and floods. At the present time a limited amount of conservation measures pertinent to flood control are being installed. These include removal of undesirable plants, reseeding, channel plantings, and construction of brush stabilizers, dikes, jetties, revetments, and small detention

and diversion dams. During the existence of the Civilian Conservation Corps, channel and erosion control improvements were installed in cooperation with that agency but effectiveness of these measures has deteriorated due to lack of maintenance.

The Bureau of Indian Affairs is responsible for about 37,000 acres of watershed lands composed of the Shivwits and Moapa Indian Reservations and that portion of the Kaibab Indian Reservation lying within the watershed. Conservation improvements are being carried out on these lands to a limited extent.

The Fish and Wildlife Service administers a desert game range in Nevada on which a limited amount of soil and moisture conservation measures are being installed.

Existing Problems.--The survey revealed that notwithstanding past and current efforts of Federal, state, and local interests major flood and erosion problems currently exist within the watershed. Further improvements are needed to:

1. Improve and protect the vegetal cover on the watershed lands to aid in the control of erosion, reduce surface runoff and restore the range, timber, and other resources these lands provide.

2. Reduce the sedimentation of reservoirs and irrigation distribution systems, check channel aggradation, and decrease the deposition of sediment on cultivated and other lands.

3. Reduce land loss resulting from gullying and bank cutting, especially on the valuable and limited cultivated and meadow lands.

4. Reduce floodwater damages to agricultural improvements, roads, railraods, and urban communities resulting largely from frequent flooding of sidewashes.

## RECOMMENDED PROGRAM

The program recommended in this report is designed to meet the needs in the Virgin River Watershed for runoff and waterflow retardation and soil erosion prevention. It consists of two groups of interrelated measures, which are designated as flood prevention measures (A Measures), and land treatment measures (B Measures).

The flood prevention measures were developed by studying representative sample areas to determine the types and quantities of measures needed and their economic feasibility. These studies assumed that the land treatment measures would be installed at a comparable rate with the installation of the flood prevention measures in order to complete the watershed program within a period of 10 years and achieve the benefits estimated in this report. A detailed study was made of the present condition of the sample watershed land and stream courses to develop the most effective means for reducing floodwater and sediment damages. The land treatment measures were developed on the basis that they would be complementary to and would be carried out concurrently with the installation of the flood prevention measures. Various combinations of measures were considered in determining the most effective and economical program for alleviating flood and sediment damage in the Virgin River Watershed.

The recommended measures, number of units, and estimated installation costs are briefly summarized in the following paragraphs.

## FLOOD PREVENTION MEASURES
## (A Measures)

The flood prevention measures consist of a series of integrated and interdependent measures which will stabilize critical runoff and sediment producing areas, reduce surface runoff, arrest channel and gully erosion, store or control sediment and provide for the temporary storage and safe passage of flood waters through urban and agricultural developments. For ease of presentation the flood prevention measures have been grouped by type of measure or location of installation.

Floodwater Retarding Structures.--In local areas where relatively high damages occur partial flood protection will be provided by constructing 32 upstream floodwater detention dams. These are small earth fill structures with concrete or masonry center or side spillways and supplemental drainage outlets. Spillways are designed to safely pass the maximum design flood. The existing Wells Siding diversion dam, canal, and Bowman Reservoir will be rehabilitated by cleaning of the canal, raising of the dikes and repair of the dam. The effectiveness of the Meadow Valley spreading grounds will be restored and enhanced by improvement of the diversion works, reconstruction of existing spurs and dikes, and the installation of additional spreaders. This work will cost about $580,800.

Stabilization and Sediment Control Measures.--There are a number of degrading channels and active headcuts in the watershed. In order to reduce the gradient and velocity in the channels or stop the headcuts, 25 large and 61 medium concrete or masonry drop

structures will be installed in the channels. These structures will also improve subirrigated meadowlands by holding the water table at an optimum level. To stabilize the small upstream channels and to facilitate vegetative control in and adjacent to the channels will require the installation of 5,042 small concrete or masonry grade stabilizers. Irrigation systems subject to severe flood and sediment damages from flooding sidewashes will be protected by the construction or improvement of 15 overshots. Cost of the stabilization and sediment control measures is estimated at $588,700.

Stream Channel Improvements.--Many of the lower tributary stream channels have insufficient capacity for the larger flood flows due to such causes as aggradation, congestion of the channels by dense trees and brush, and general encroachment of urban and rural improvements. Channel improvements to protect high value areas were found to be feasible along channels aggregating 27 miles in length. Channel measures to be used singly or in combination include realignment of the channel, enlargement of channel sections, and the removal of sediment, brush, and other obstructions. Bank cutting will be arrested and the sediment producing channels stabilized by the installation of 54 miles of bank protection and the establishment of vegetation along 75 miles of upstream eroding channel banks. Estimated cost of stream channel improvements is $666,600.

Diversion Ditches and Dikes.--In the small waterways, where conditions are favorable, 14,615 diversion ditches and 355 miles of diversion dikes will be installed at an estimated cost of $731,900. These small ditches and dikes are designed to divert

surface runoff from concentrating in gullies and to spread it on adjacent areas.

Floodways.--Nine miles of levees will be installed along channels to control flood flows in excess of channel capacities. This measure is used either alone or in combination with other channel improvement measures depending upon local conditions. Levees will be constructed of earth with sufficient freeboard to safely pass the maximum design flood. The estimated cost is $104,700.

Stabilization of Critical Runoff and Sediment Producing Areas.--Critically depleted areas will be stabilized by seeding 166,000 acres to adapted perennial grasses, contour trenching, and seeding of 985 acres, the installation of 59,600 rock and brush dams, and erosion control structures and vegetative plantings on slopes will be installed on about 1,872 miles of road and 102 miles of stock driveways. To insure establishment and protection of the vegetative measures, rodents will be controlled on 120,900 acres and 150 miles of protective fence will be constructed. Because of their critical conditions, these areas are not now suitable for grazing use by domestic livestock and their use by big game should be reduced. Estimated cost of this work is $2,367,200.

## LAND TREATMENT MEASURES
(B Measures)

Proper land management provides the key to the improvement of lands in the watershed. [redacted] The adjustment of grazing use by

livestock and big game so as to permit restoration and maintenance of an adequate vegetal cover is prerequisite to other range land measures. There are 1,315,000 acres in the watershed which are unsuitable for grazing domestic livestock. Much of this area, because of natural barriers has received only rare use by livestock in the past. The remainder cannot withstand the pressure of any type of use and still retain its naturally sparse vegetal cover. In the past, the inclusion of this land in the determination of grazing capacities and use based upon these estimates has resulted in overuse of the better grazing lands with subsequent deterioration of such lands. Use on approximately 1,200,000 acres will need to be temporarily adjusted downward with exclusions on seeded areas while vegetation is being reestablished.

Revegetation of Depleted Areas.--Seeding of depleted areas to desirable perennial grasses so as to check erosion and runoff and increase forage production is needed on 245,840 acres. Preparation of this land for seeding includes the removal of undesirable plant competition. On 34,000 acres competition reduction alone is necessary to increase forage production. To insure establishment of stands on the seeded area, rodents will need to be controlled on about 120,900 acres. Estimated cost of the vegetal measures is $1,649,800.

Livestock Management Measures.--Proper management and distribution of livestock and big game will require the installation of 328 water developments, construction of 2 counting corrals,

establishment of 6 miles of stock trails, and the construction of 994 miles of line and division fence at a cost of about $739,100.

Fire Control.--Additional fire control facilities are needed on all lands and especially on the desert shrub and woodland types. Additional protection is especially needed on these semi-desert areas due to the slow recovery of the vegetal cover following fire and the serious erosion which results when intense summer storms occur on the burned areas. The additional mobile equipment tools and supplies will cost about $54,500. The annual cost of operation, maintenance, and replacement will be about $17,400. The cost of installing and maintaining this measure will be in addition to regular agency activities.

Cultivated Land Measures.--To aid in the reduction of flood and sediment damages and to conserve the cultivated lands, crop residue will be managed on 15,000 acres and 575 miles of farm terraces will be constructed on the sloping dry-farm lands. To control gully erosion on and adjacent to dry-farmed lands, 1,600 small erosion control dams, 253 grade stabilizers and 200 acres of grassed waterways and outlets will be installed. To improve production and to reduce on-site erosion and the production of sediments from irrigated areas 4,800 acres will be leveled. Cultivated land treatment measures will cost about $628,600.

Technical Services.--Additional technical personnel will be needed to plan and install the recommended measures on Federal land. Technicians will also be needed to assist and advise private landowners in the installation of measures on private lands. The

estimated cost of these services during the installation period is $504,100. The cost of providing and maintaining the technical services on forest land will be in addition to the technical services provided by regular agency activities.

Educational Assistance.--Landowners, operators, and other groups will be furnished educational assistance relative to the need for the recommended program and its purpose and objectives. Information will be supplied as to the manner in which landowners and operators now obtain services and assistance that are available through the various Governmental agencies, and how they can and should by their own efforts contribute successfully and most economically to the accomplishment of the over-all objectives. Intensified educational efforts will be directed to familiarizing farmers with the specific practices and measures essential to runoff and waterflow retardation and soil erosion prevention and how to install and apply those measures not requiring the assistance of a specialized technician. How to maintain such installations and measures will be emphasized and instructions will be provided on how to integrate them into a sound farm management system to produce the greatest benefits over a long period of time.

## COST OF RECOMMENDED PROGRAM

The estimated cost of installing both the flood prevention measures and the land treatment measures is $8,740,400. It is estimated that local interests will provide 51 percent of the cost of installing these measures on non-Federal land; however, the allocation of Federal and non-Federal costs will vary by types of

measures. The cost of installing land treatment measures on non-Federal land will generally be borne in large part by individual landowners and operators since a large part of the benefit will accrue directly to the land on which the measures are applied. Flood prevention measures, however, produce public benefits often of a dispersed nature, and extending far downstream. The Federal Government will install these latter measures on non-Federal land on a cost-sharing basis, and will provide a larger share of the cost of installation than in the case of land treatment measures. The cost of installing, operating, and maintaining the flood

(Continued on page 37)

prevention measures on Federal land will be borne by the agencies responsible for the administration of such land.

## FLOOD PREVENTION MEASURES
(A Measures)

The estimated cost of installing the flood prevention measures is $5,040,100. (See table 3.) Of this cost it is estimated that the Federal Government will expend $2,621,100 on Federal land and $1,706,000 on non-Federal land, and that local interests will expend $713,000 on non-Federal land.

Local interests will be required to furnish without cost to the Federal Government all lands, easements, and rights-of-way needed in connection with the installation of the flood prevention measures; and will be expected to make any additional contributions that may be necessary to meet their proportionate share of the cost of installing these measures as determined by the Secretary of Agriculture to be equitable in consideration of the anticipated benefits from such measures.

The estimated annual Federal cost of operating and maintaining these measures on Federal land is $30,400. The estimated annual cost of operating and maintaining these measures on non-Federal land is $29,420 which will be borne by local interests.

## LAND TREATMENT MEASURES
(B Measures)

The estimated cost of installing the land treatment measures is $3,700,300. (See Table 4.) Of this cost it is estimated that the Federal Government will expend $1,686,800 on Federal land and $271,700 on non-Federal land; and that local interests will expend

Table 3.--ESTIMATED COST OF INSTALLING FLOOD PREVENTION MEASURES
(A Measures)
Virgin River Watershed, Utah, Nevada and Arizona
(Projected Long Term Prices)

| Measure | Unit | Quantity | COST | | |
|---|---|---|---|---|---|
| | | | Federal | Non-Federal | Total |
| | | | (Dollars) | | |
| Floodwater Retarding Structures | | | | | |
| Federal land | No. | 9 | 292,500 | - | 292,500 |
| Non-Federal land | No. | 25 | 259,500 | 28,800 | 288,300 |
| Stabilization and Sediment Control Measures | | | | | |
| Federal land | No. | 4,631 | 413,200 | - | 413,200 |
| Non-Federal land | No. | 497 | 128,300 | 47,200 | 175,500 |
| Stream Channel Improvements | | | | | |
| Federal land | Mile | 41 | 69,600 | - | 69,600 |
| Non-Federal land | Mile | 114 | 390,800 | 206,200 | 597,000 |
| Diversion Ditches and Dikes | | | | | |
| Federal land | No. | 14,305 | 644,700 | - | 644,700 |
| Non-Federal land | Text p. 32 | | 60,800 | 26,400 | 87,200 |
| Floodways | | | | | |
| Federal land | Mile | 1 | 4,700 | - | 4,700 |
| Non-Federal land | Mile | 8 | 90,200 | 10,000 | 100,200 |
| Stabilization of Critical Run-off and Sediment Producing Areas | | | | | |
| Federal land | Text p. 33 | | 1,196,400 | - | 1,196,400 |
| Non-Federal land | Text p. 33 | | 776,400 | 394,400 | 1,170,800 |
| Subtotal Federal land | | | 2,621,100 | - | 2,621,100 |
| Subtotal non-Federal land | | | 1,706,000 | 713,000 | 2,419,000 |
| TOTAL | | | 4,327,100 | 713,000 | 5,040,100 |

Table 4.--ESTIMATED COST OF INSTALLING LAND TREATMENT MEASURES
(B Measures)
Virgin River Watershed, Utah, Nevada and Arizona
(Projected Long Term Prices)

| Measure | Unit | Quantity | Cost | | |
|---|---|---|---|---|---|
| | | | Federal | Non-Federal | Total |
| | | | (Dollars) | | |
| Forest and Range land | | | | | |
| Revegetation of depleted areas | | | | | |
| Federal land | Acre | 202,653 | 788,900 | 231,900 | 1,020,800 |
| Non-Federal land | Acre | 75,019 | - | 629,000 | 629,000 |
| Livestock Management Measures | | | | | |
| Federal land | Text | | 548,900 | 174,900 | 723,800 |
| Non-Federal land | Text | | - | 15,300 | 15,300 |
| Fire Control | | | | | |
| Federal land | | | 54,500 | - | 54,500 |
| Cultivated land | | | | | |
| Non-Federal land | Text | | - | 628,600 | 628,600 |
| Technical Services | | | | | |
| Federal land | | | 294,500 | - | 294,500 |
| Non-Federal land | | | 209,600 | - | 209,600 |
| Educational Assistance | | | | | |
| Non-Federal land | | | 62,100 | 62,100 | 124,200 |
| Subtotal Federal land | | | 1,686,800 | 406,800 | 2,093,600 |
| Subtotal Non-Federal land | | | 271,700 | 1,335,000 | 1,606,700 |
| TOTAL | | | 1,958,500 | 1,741,800 | 3,700,300 |

$406,800 on Federal land and $1,335,000 on non-Federal land. The estimated Federal cost of these measures on non-Federal land does not include financial assistance by the Federal Government such as payments to landowners and operators by the Agricultural Conservation Program Service. Any assistance of this kind that may be provided at the time of program installation will help landowners and operators in installing the program.

The estimated annual cost of operating and maintaining these measures is $176,500. Of this amount, it is estimated that the Federal Government will expend $45,000 on Federal land and $700 on non-Federal land; and that local interests will expend $130,800 on non-Federal land.

## BENEFITS FROM THE RECOMMENDED PROGRAM

The future improved hydrologic conditions of the watershed resulting from installation of the recommended remedial program will be directly reflected in lessened flood and sediment damage. These benefits will accrue with reductions in the magnitude and frequency of floods and by decreased erosion which produces damaging sediments. Treatment measures will improve plant cover and increase soil stability resulting in higher infiltration rates and decreased erosion. In addition, conservation benefits resulting from increased productivity of watershed lands will be realized and the over-all effect will be of a permanent nature. The structural measures will temporarily detain floodwater, provide sediment storage, reduce erosion on roads, and protect urban areas and agricultural developments.

The changed conditions which are expected in the future after the program becomes fully operative will be reflected directly in a reduction of annual flood and sediment damages by about 48 percent. The estimated annual future benefits that will result from the program are listed in table 5. Attainment of these expected benefits is dependent on the installation and proper maintenance of all recommended program measures.

Nonevaluated Benefits.--In addition to the benefits that can be evaluated monetarily, there are many others which will accrue to the local people if adequate protection from surface runoff and erosion is provided. The monetary approach does not fully consider many benefits which are inherent in the local and regional economy and which contribute to the justification for the program. These include:

(1) Extended usefullness of the water supply reservoirs and facilities essential to the permanency of the area's irrigation agriculture and its dependent economy.

(2) Greater stability of agriculture and associated business.

(3) Reduction in the severity of drainage problems along the main channels.

(4) Enhanced recreational opportunities, especially hunting.

(5) Greater security of life and health.

A more detailed description of these unevaluated benefits follows:

(1) On an area basis the Virgin River is among the highest sediment producers of the Colorado River tributaries above Lake Mead. The excessive amount of sediment carried by the streams has thus far been a primary factor in preventing the development of adequate water storage facilities within the watershed.

Table 5.--ESTIMATED AVERAGE ANNUAL MONETARY BENEFITS
FROM THE RECOMMENDED PROGRAM
Virgin River Watershed, Utah, Nevada and Arizona
(Projected Long Term Prices)

| Type | Average Annual Benefits |
|---|---|
| | (D o l l a r s) |
| Agriculture | 52,300 |
| Urban | 3,600 |
| Utilities and Public Property | 11,700 |
| Railroads | 11,800 |
| Roads and Highways | 45,400 |
| Flood Protection Works | 2,800 |
| Sediment Reduction, Canals | 18,800 |
| Sediment Reduction, Reservoirs | 66,500 |
| Range Conservation | 139,200 |
| Cropland Conservation | 255,400 |
| Total | 607,500 |

As indicated previously, monetary benefits to reservoirs from reduced sedimentation were evaluated on the basis of the capital value of storage capacity. The latter was determined by the application of current construction costs.

As a result of additional usable water provided by Lake Mead and complementary structures, hundreds of millions of dollars have been invested in the lower portion of the Colorado Basin in irrigation and domestic water distribution systems, irrigated farms, homes, schools, churches, processing plants, places of business and communication, and transportation facilities. All this development is dependent in large measure upon Lake Mead and supplementary reservoirs for a continuous supply of water. Cities such as Los Angeles, San Diego, and many other smaller communities of southern California, although outside the Colorado River Watershed, obtain an important part of their municipal water and electric power from Lake Mead. Perpetuation of the facilities provided by this reservoir through maximum feasible control of sediment deposition is therefore of extreme importance to the preservation of present economic life in southern California. It is even more important to further growth in population, industry, and municipal development in that area.

Present indications are that to replace the storage capacity of Lake Mead would require the construction of several large upstream reservoirs. Contemplated developments required to utilize the share of Colorado River water allocated to the upper basin states will reduce the number of sites which could otherwise be used as replacements for Lake Mead. Future construction of replacement reservoirs at less

desirable sites will therefore involve construction costs per acre-foot of capacity considerably higher than the costs for Hoover Dam. Total operation and maintenance costs would undoubtedly be greatly increased. Total evaporation losses will be much greater due to the increased area of water surface. The importance of evaporation losses is indicated by the average loss of 546,362 acre-feet annually from Lake Mead for the years 1941 to 1947 inclusive. The present sediment contribution to Lake Mead by the Virgin River and its tributaries is estimated at 5,750 acre-feet annually. While this represents a relatively small part of the total, reduction of sediment contributions from the Virgin River Watershed will help prolong the beneficial life of this very valuable reservoir.

(2) Gully erosion which is undermining the productive base and economic stability of the watershed through destruction of the limited area of mountain meadows and irrigated valley floors will be arrested by the program. Because of the relatively small size of individual farms, the loss of even one acre of this type of land has a detrimental effect on farm income far beyond the actual sale value of the land.

(3) Reduction in deposition of sediment along reaches of streams with low gradient will reduce the drainage problem on adjacent cultivated lands and will permit more extensive use of waterlogged land.

(4) During 1949 the estimated number of big game spending part of the time in the watershed consisted of 20,000 deer, 250 elk, and 100 mountain sheep. The proposed flood control program recommends

adjusting numbers of big game using watershed range lands to conform with the safe carrying capacity of these lands. It provides for additional fire protection and revegetation of depleted slopes and stream bottoms by seeding and by shrub and tree planting. In addition to the primary objective of flood and sediment reduction, these measures will provide increased amounts of forage for big game use. The additional forage may allow a sustained increase in the carrying capacity of watershed lands for big game equivalent to about 1,600 head which would provide an increased annual harvest of about 400 head.

In view of the many intangible factors which enter into any discussion of recreation, it is very difficult to make a monetary evaluation of this benefit. Providing services to hunters is an established economic enterprise in the watershed and the increased income so derived forms an important part of the livelihood of many local residents. The area is used extensively by nonlocal hunters.

(5) Loss of life as a direct result of floods has occurred within the watershed. Flooding of residential areas has created unsanitary conditions and increased the susceptibility to disease. These hazards to life and health will be lessened by reduction in flood peaks which will be accomplished by the program.

It is estimated that the proposed program will result in a reduction of present sediment rates by about 40 percent. Flood peaks will also be reduced. The social and economic value of these benefits cannot be fully evaluated in monetary terms but their importance in the Virgin River Watershed and to the lower Colorado

River basin is unquestionable. In the final analysis the long-time social and economic value of these nonevaluated benefits may equal or exceed the value of benefits as estimated in monetary terms.

## COMPARISON OF BENEFITS AND COSTS

The estimated annual benefits total $607,500 and the annual costs of installation and maintenance total $486,110. The ratio of the benefits evaluated in this report to the costs is 1.25 to 1. This ratio has been computed on the basis of projected long term prices.